New Methodology for Computing Thickness of Flexible Overlays of Military Airfield Flexible Pavements

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Carlos Gonzalez , PE
US Army Engineer Research and Development Center
Vicksburg, MS

Dr. Alessandra Bianchini, PE
Air Force Civil Engineer Center
Tyndall AFB, FL

US Army Corps of Engineers
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Flexible Pavement Overlay

- Pavement overlay
  - Primary technique utilized in pavement maintenance
  - Increases the structural support of the pavements (design traffic growth or mission change)
- Design of pavement overlays
  - UFC 03-260-02 *Pavement Design For Airfields*
  - Based on empirical formulation
- Flexible overlay thickness based on
  - Thicknesses of the existing asphalt, base, and subbase layers
  - Required minimum thickness for the asphalt layer

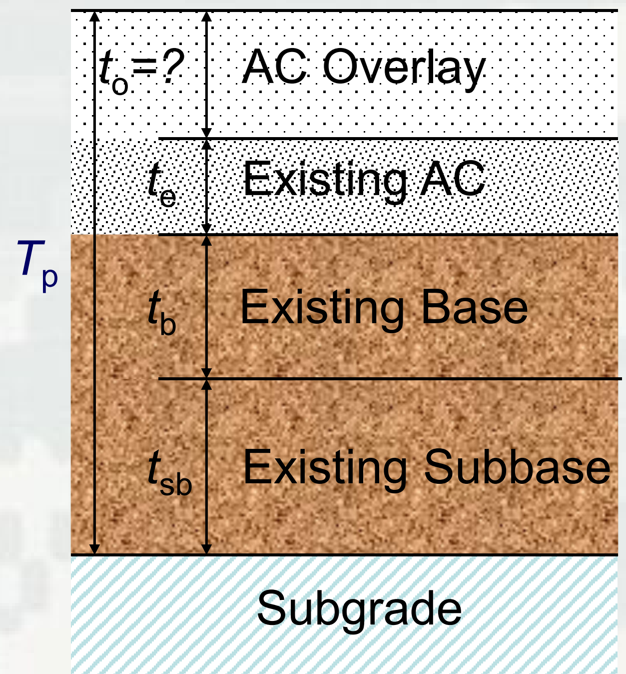
Purpose of the Study

- Improve methodology for computing the flexible overlay thickness considering the structural condition of the existing asphalt layer
- Standardize the design and evaluation of flexible pavements overlaid with asphalt layers and account for existing structural conditions
- Help overall optimization of maintenance funding allocation limiting pavement overdesign

Flexible Overlay over Flexible Pavement Design Manual UFC 3-260-02

$$T_p = t_m + (t_o + t_e - t_m)E_f + t_b + t_{sb} \qquad (1)$$

T_P – total thickness required above the subgrade
t_m – minimum thickness of asphalt
t_o – thickness of overlay
t_e – thickness of existing asphalt
E_f – equivalency factor for converting asphalt to an equivalent thickness of subbase
t_b – thickness of existing base
t_{sb} – thickness of existing subbase



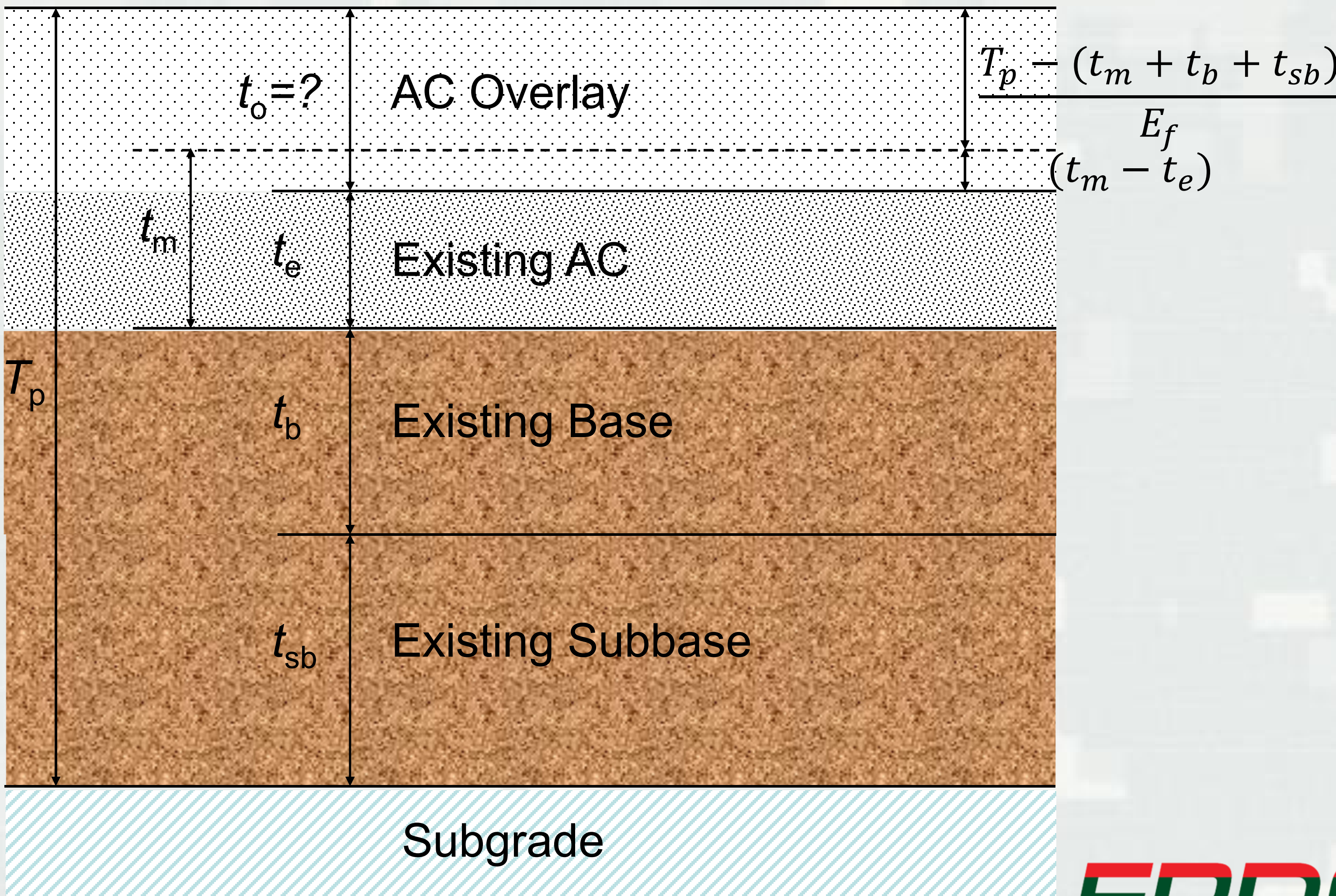
Flexible Overlay Equation

$$T_p = t_m + (t_o + t_e - t_m)E_f + t_b + t_{sb} \qquad \text{(1bis)}$$

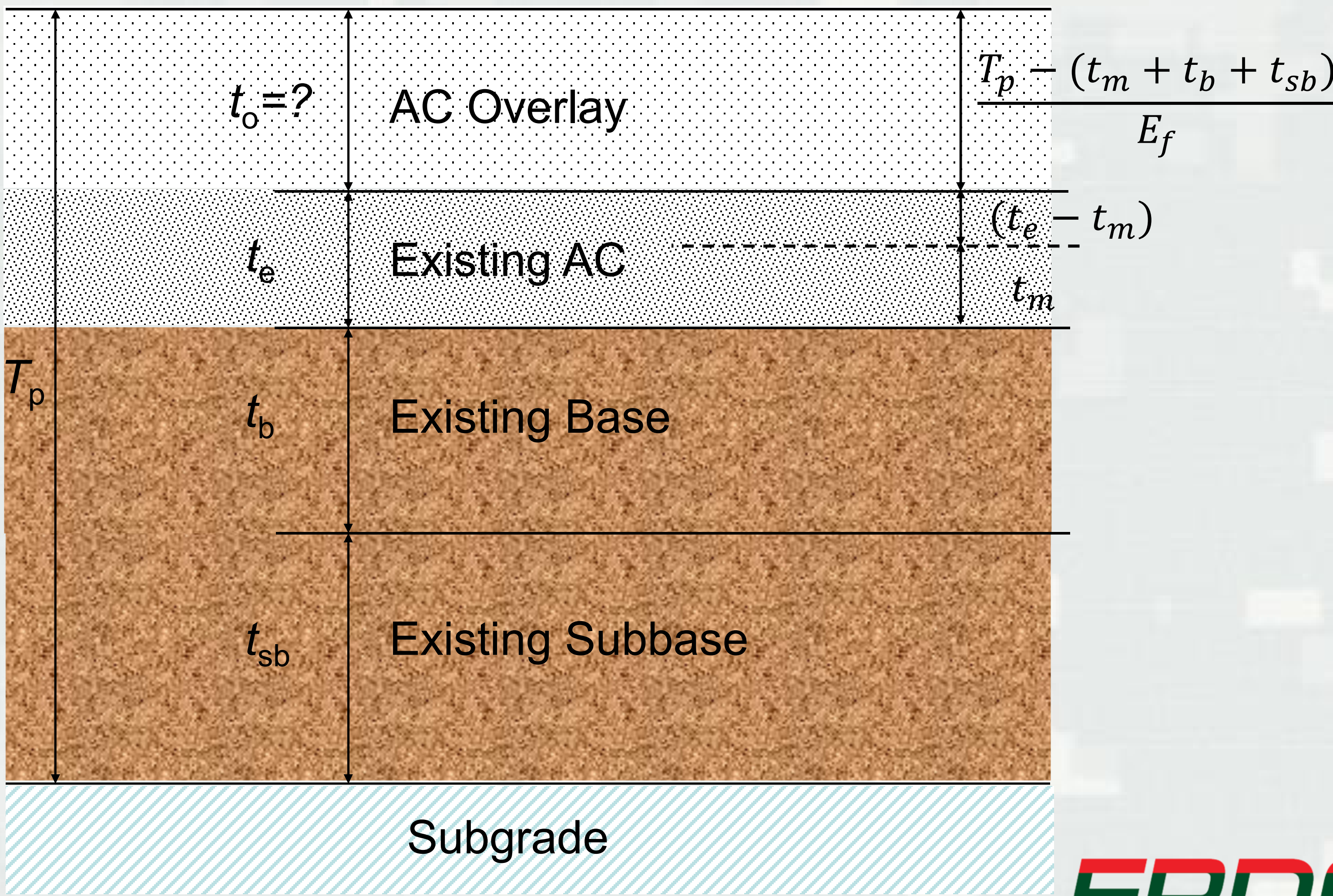
Solving Equation 1 for t_o:

$$t_o = \frac{T_p - (t_m + t_b + t_{sb})}{E_f} + (t_m - t_e) \qquad \text{(2)}$$

Equation 1 Explained: Case 1, $t_m > t_e$



Equation 1 Explained: Case 2, $t_m \leq t_e$



Limitations of the Current Methodology

- Does not take into account the quality or the *structural condition* of the existing asphalt layers
- Considers the asphalt layer to have full strength support and no deterioration

Approach

- Computation of the flexible overlay thickness through the introduction of an *asphalt reduction factor*
- *Asphalt reduction factor*
  - ► Quantifies the amount of the existing asphalt layer thickness that can still offer structural support
  - ► Can be based on distresses affecting the asphalt surface
  - ► Selected distresses commonly monitored during pavement evaluations

Flexible Pavement Overlay

$$t_o = \frac{T_p - (t_m + t_b + t_{sb})}{E_f} + (t_m - t_e) \qquad \textbf{(2 bis)}$$

Extending Equation 2 to multiple bases, subbases, and introducing the asphalt reduction factor, Equation 3 is obtained:

$$t_o = \frac{T_p - [t_m + (\sum t_b + (1 - f_{ac})t_e) + \sum t_{sb}]}{E_f} + (t_m - f_{ac} t_e) \qquad \textbf{(3)}$$

Where: $0.0 \leq f_{ac} \leq 1.0$

Asphalt Reduction Factor, f_{ac}

If f_{ac} = 1.0

- Existing AC layer is in good condition, monolithic structure,
- full AC thickness contributes to the AC overlay

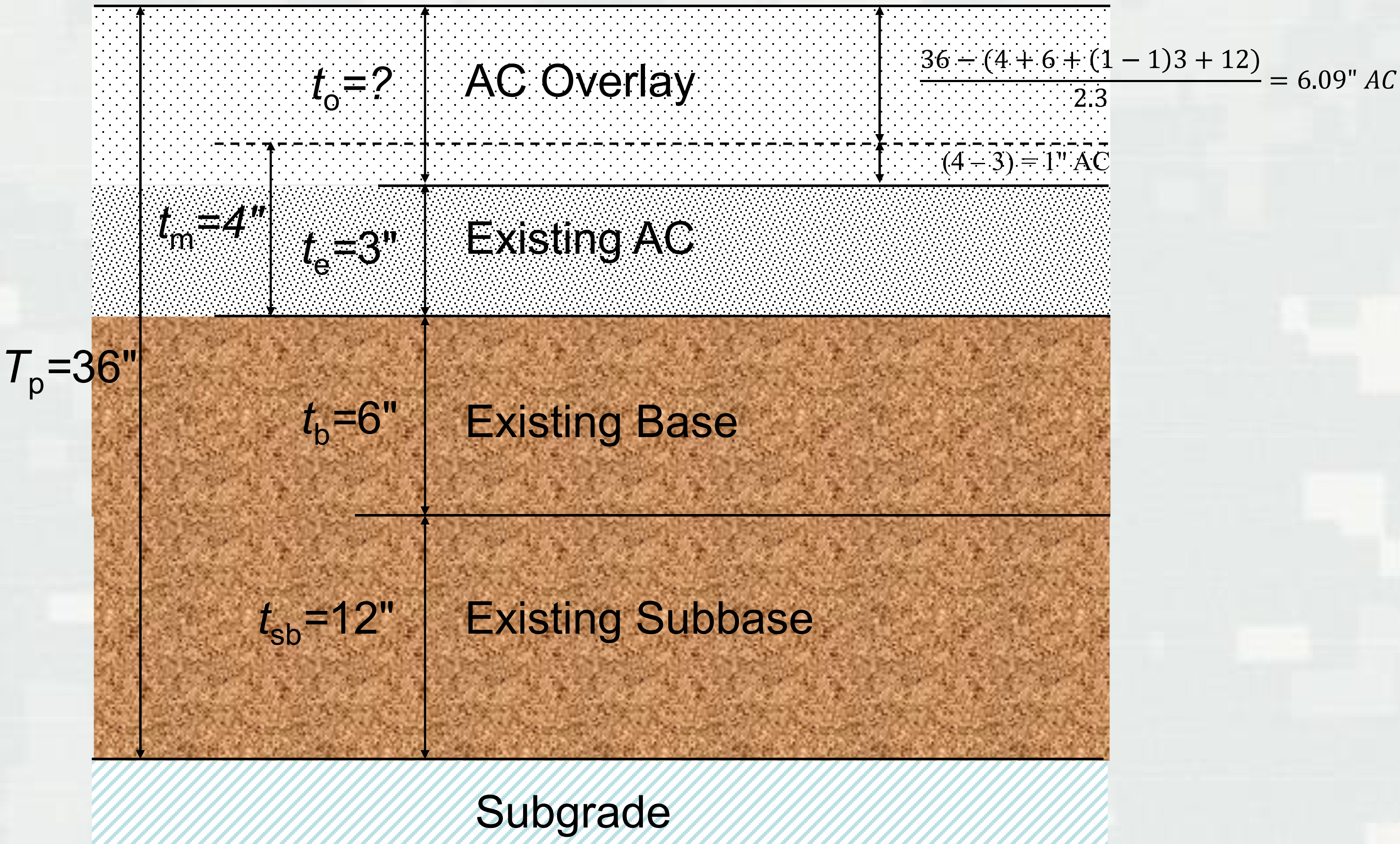
If f_{ac} = 0.0

- Existing AC layer is in poor condition,
- No thickness can contribute to the overlay,
- All asphalt layer thickness is considered a base and is added to the existing base

Built-in Assumptions

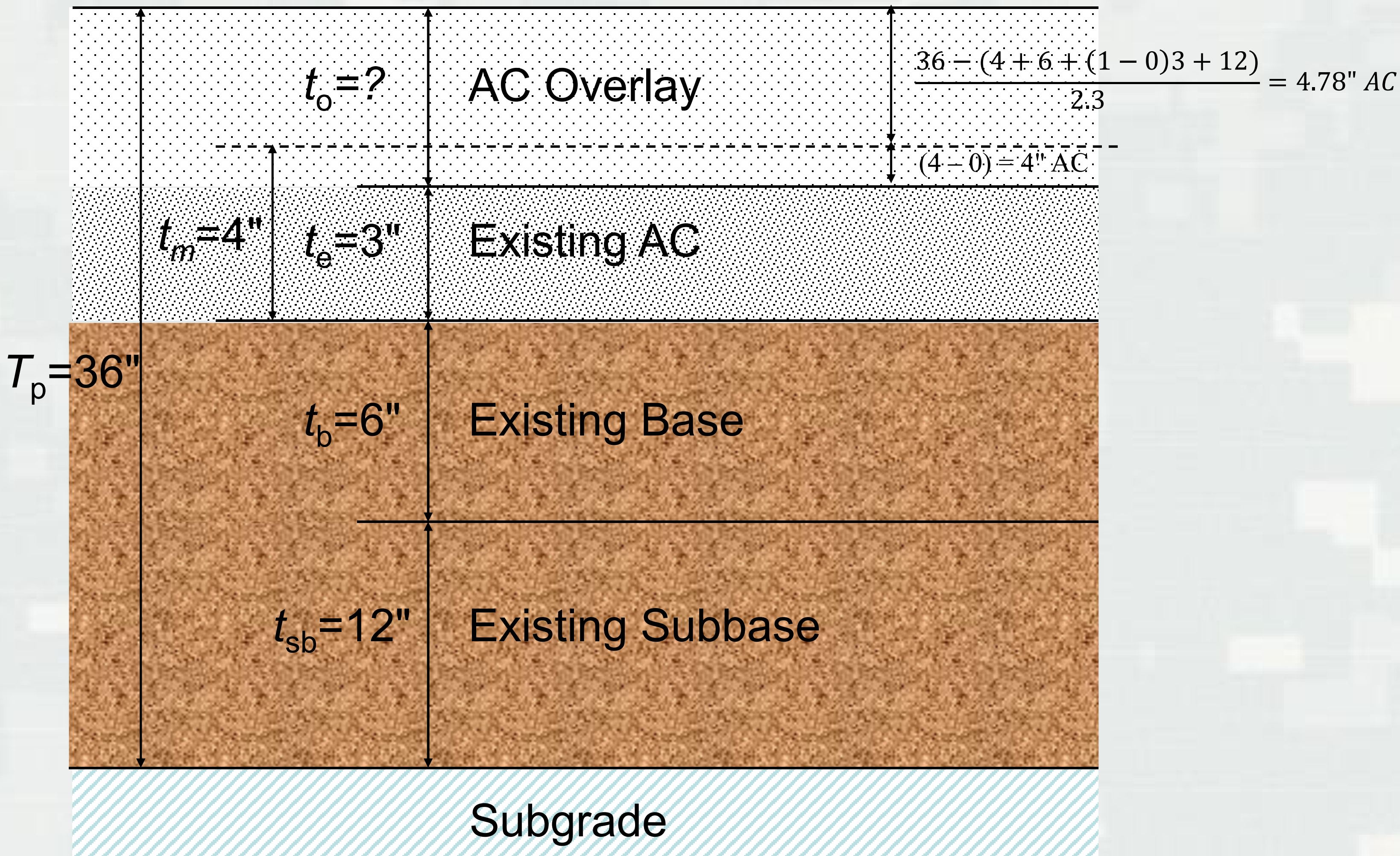
- When using f_{ac} , AC is converted to base with CBR=100 for values less than 1.0
- An existing base must have CBR>80 to be called a base; otherwise, it should be treated as a subbase layer

Example Assuming $f_{ac} = 1.0$



$$t_o = \frac{36" - [4" + (6" + (1-1)3") + 12"]}{2.3} + (4" - 3") = 6.09" + 1" = 7.09"\ AC$$

Example Assuming $f_{ac} = 0.0$



$$t_o = \frac{36\text{"} - [4\text{"} + (6\text{"} + (1-0)3\text{"}) + 12\text{"}]}{2.3} + (4\text{"}) = 4.78\text{"} + 4\text{"} = 8.78\text{"}\ AC$$

AC Layer Condition Analysis

AC layer in poor condition, $f_{ac\,c} = 0$ AC layer in good condition, $f_{ac} = 1$

$$t_{o0} - t_{o1} = \frac{T_p - [t_m + (\sum t_b + t_e) + \sum t_{sb}]}{E_f} + t_m - \frac{T_p - [t_m + \sum t_b + \sum t_{sb}]}{E_f} - (t_m - t_e)$$

With equivalency factor, $E_f = 2.3$ (asphalt concrete to subbase):

$$t_{o0} - t_{o1} = t_e\left(1 - \frac{1}{E_f}\right) = t_e\left(1 - \frac{1}{2.3}\right) = 0.565 t_e$$

With respect to the existing AC thickness, an AC layer in poor condition requires about 60% more in thickness than an AC in good condition

Examples

Pavement Layers	Example 1 Thickness, inches	Example 2 Thickness, inches
AC existing (t_e)	3	5
Base existing (t_b)	6	6
Subbase existing (t_{sb})	12	12
AC minimum thickness (t_m)	4	4
Total thickness needed (T_p)	35	35

	Overlay, inches											
f_{ac}	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	t_o-t_1
Example 1	8.35	8.18	8.01	7.84	7.67	7.50	7.33	7.16	6.99	6.82	6.65	1.70
Example 2	7.48	7.20	6.91	6.63	6.35	6.07	5.78	5.50	5.22	4.93	4.65	2.83

Determination of the Asphalt Reduction Factor, f_{ac} *for values between 0.0 and 1.0*

- The asphalt layer is weakened in the presence of the *Selected Distresses* (cracking distresses) ➔ distress relative area with respect to the other existing distresses

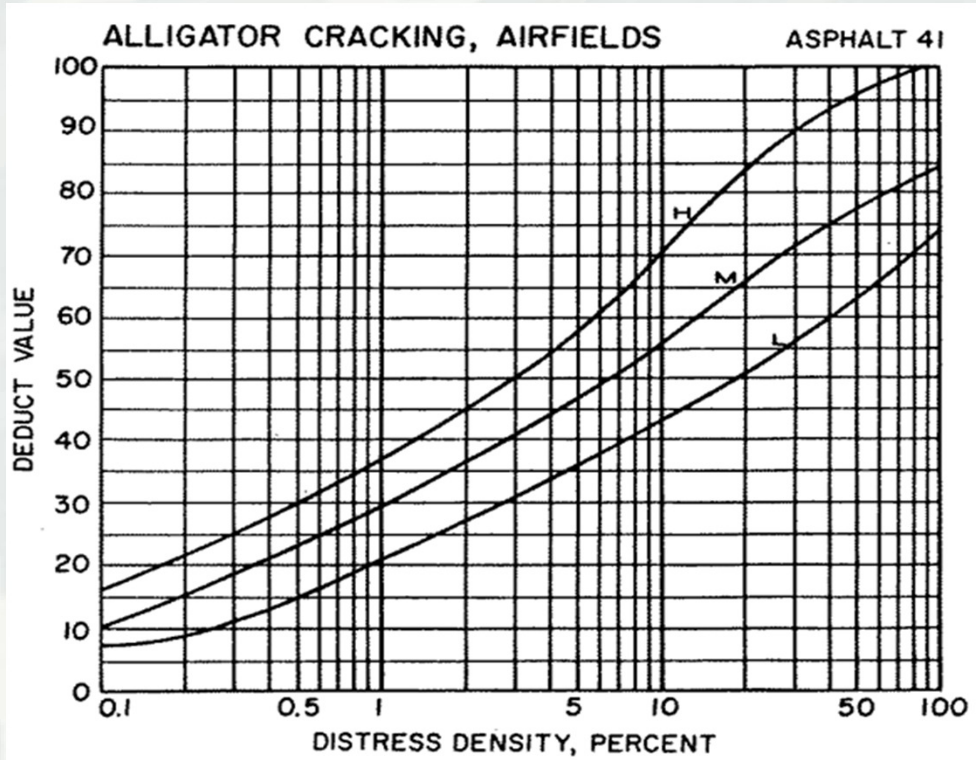
- The *asphalt reduction factor* is a function of the RATIO between the area of *Selected Distresses* and the total area of distresses

$$f_{ac} = function\left(\frac{Relative\ area\ of\ selected\ distresses}{Total\ area\ of\ distresses}\right)$$

Selected Distresses

Based on distresses diminishing the integrity of the asphalt layer

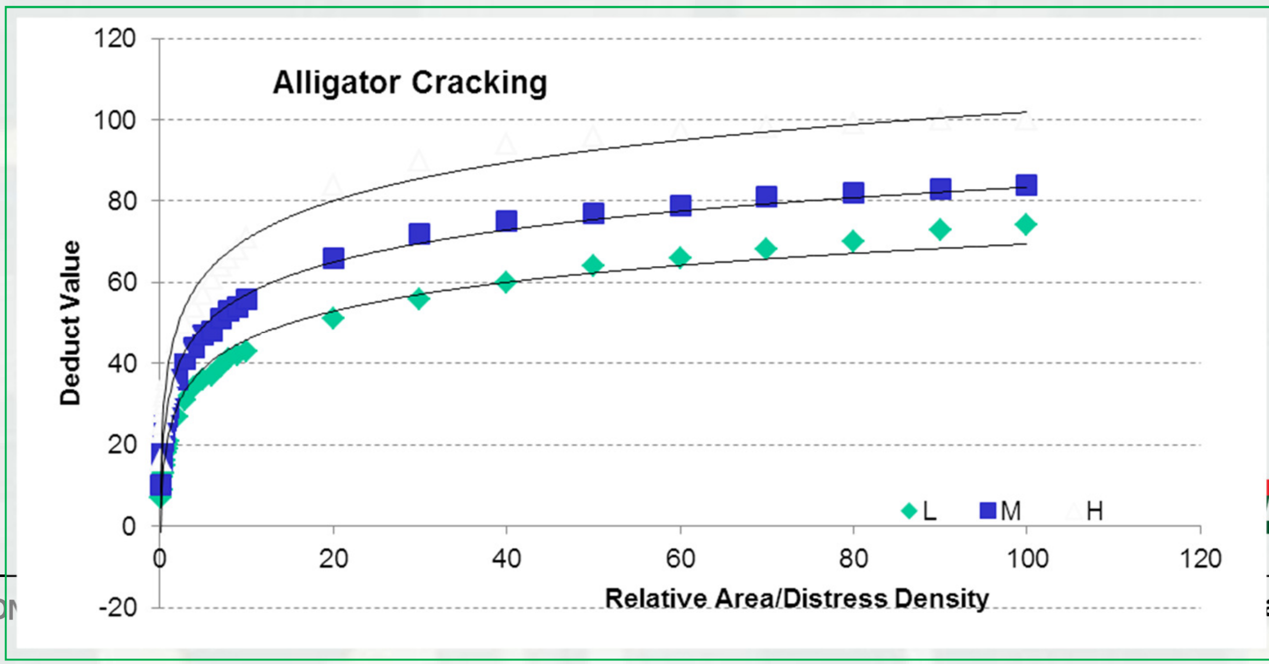
- Alligator cracking
  - @10% of distress density →Deduct Value (DV) is 43(L), 56(M), and 71(H)
- Block cracking
  - @10% of distress density →DV is 17(L), 24(M), and 42(H)
- Joint reflection
  - @10% of distress density →DV is 16(L), 38(M), and 55(H)
- Long./Transv. cracking
  - @10% of distress density →DV is 24(L), 36(M), and 54(H)



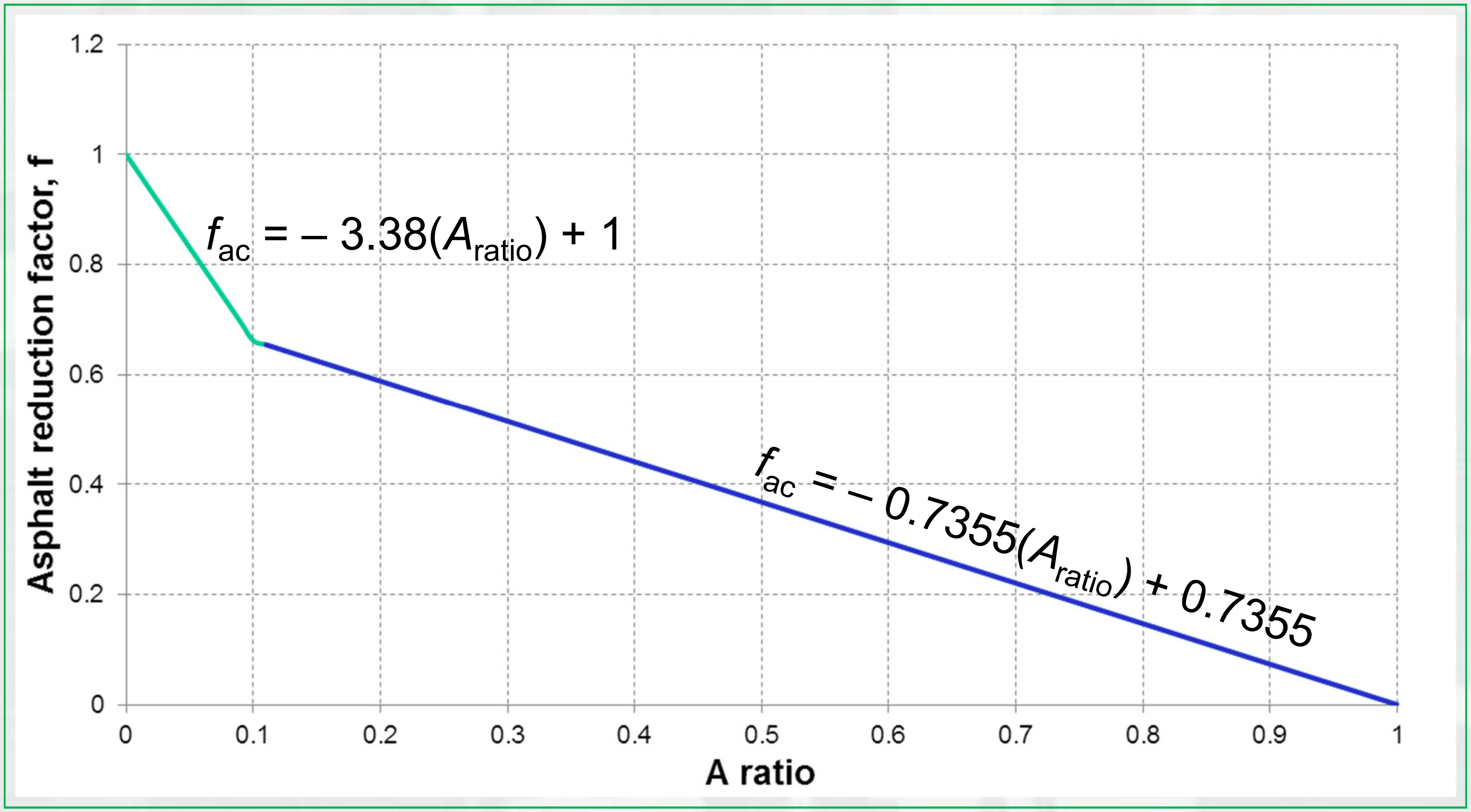
Selected Distresses

- Alligator cracking
- Block cracking
- Joint reflection
- Longitudinal and Transverse cracking

- For each distress, DV rapidly increases with the first 10% of Distress Density (DD) increase → PCI rapidly decreases
- DD increase 0-10%, the DV increase average rate 3.38
- DD increase 10-20%, 20-30%, DV increase average rate 0.7355



Asphalt Reduction Factor f_{AC}



$f_{ac} = -3.38(A_{ratio}) + 1$ for $A_{ratio} \leq 0.1$

$f_{ac} = -0.7355(A_{ratio}) + 0.7355$ for $A_{ratio} > 0.1$

$$A_{ratio} = \frac{\text{Selected Distress Area}}{\text{Total Distress Area}}$$

Conclusions

- An asphalt reduction factor, f_{ac}, was defined as a function of the distresses affecting the existing asphalt surface and their severity and extent
- The distresses included those that clearly undermine the soundness of the asphalt layer and included cracking type distresses:
  - alligator cracking, block cracking, joint reflection cracking, and longitudinal and transverse cracking
- According to the procedure outlined, an asphalt layer in poor condition would require about 60% more in thickness than an asphalt layer in good condition

Questions?